Suggested Actions

To best avoid or mitigate voltage overshoots, consider locating the drive close to the motor. Where this is not possible, consider installing filtering devices such as:

- line inductors at the drive end of the cable
- harmonic suppression filters at the motor end of the cable.

Eliminate problems of current flow across the rolling elements of the motor's bearings by isolating both bearings or using a shaft-grounding brush.

Resources

U.S. Department of Energy—For additional information or resources on motor and motor-driven system efficiency improvement measures, visit the BestPractices Web site at www.eere.energy.gov/industry/bestpractices, or contact the EERE Information Center at (877) 337-3463.

National Electrical Manufacturers Association (NEMA)—Visit the NEMA Web site at www.nema.org for information on motor standards, application guides, and technical papers.

Minimize Adverse Motor and Adjustable Speed Drive Interactions

Electronic adjustable speed drives (ASDs) are an extremely efficient and valuable asset to motor systems. They allow precise process control and provide energy savings within systems that do not need to continuously operate at full output.

The most common ASD design sold today is the pulse-width modulated (PWM) ASD with a fast rise-time insulated gate bipolar transistor (IGBT) to reduce switching losses and noise levels. However, higher carrier frequencies and faster rise time transistors on PWM ASDs can produce voltage spikes or overshoots that can stress motor windings and bearings. These problems can be eliminated through proper design and equipment selection.

Electronic Adjustable Speed Drive Characteristics

All electronic adjustable speed drives rectify the 60 Hz fixed voltage alternating current (AC) to direct current (DC), and use an inverter to simulate an adjustable frequency and variable voltage AC output. Transistors, or electronic "switches," create the AC voltage output, but have very high losses when they create wave shapes other than square waves.

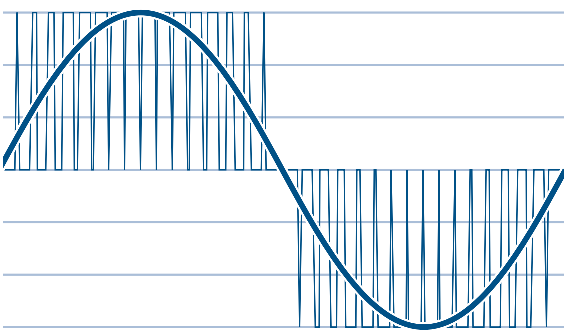

Figure 1. Sine wave overlaid on square carrier waves

To minimize switching losses and approximate sine waves, ASDs operate these switches full-on or full-off, creating square waves of much higher frequency than the fundamental, usually between 2 kHz and 20 kHz. This is called a carrier wave (see Figure 1). Each on-portion of the carrier wave is called a pulse and the duration of on-time of each pulse is called the pulse width. The pulses do not turn on instantaneously; there is a brief rise time.

Different types of transistors used in drives have different rise times. Voltage spikes originate with fast rise time, and carrier frequencies above 5 kHz are likely to cause bearing damage unless protective measures are taken.

Design Considerations

Several design considerations should be taken into account when purchasing an ASD or fixing problems with an existing one. On new installations, ensure that no harm comes to motors by minimizing the cable length from the ASD to the motor. As shown in Figure 2, ASDs can produce voltage overshoots or spikes with the increase over the normal peak voltage dependent upon both cable length and carrier frequency.

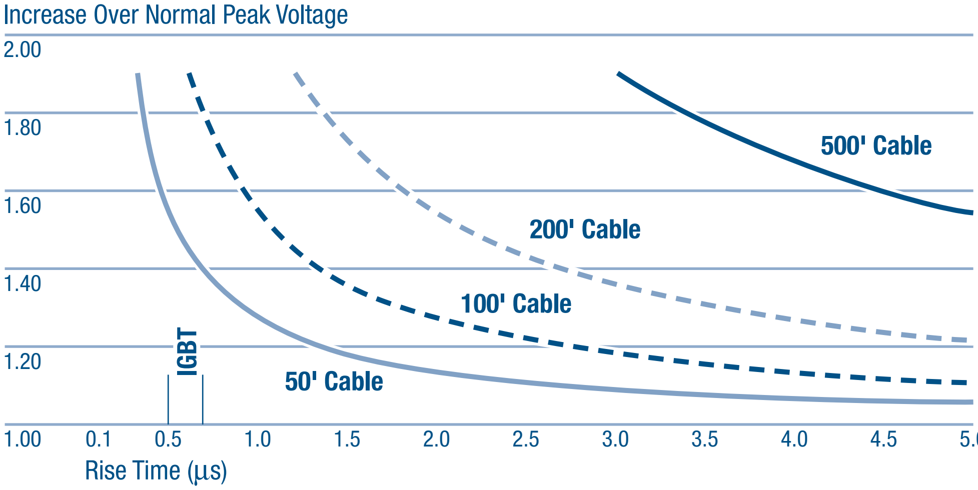

Figure 2. Effect of cable length on voltage increase

In Figure 2, the voltage increase is plotted against rise time in microseconds. Rise time is the time required for the voltage to increase from 10% to 90% of its steady state value. The rise time is a characteristic of the power transistor switches and can be provided by the drive supplier. Modern IGBT switches operate well down toward the left side of the graph so cable lengths of 50 feet or more almost always need mitigation.

Longer cables reflect the voltage rise so that the reflections reinforce the original pulse rise. This produces electrical resonance or "ringing" characterized by an oscillating voltage overshoot. With short cables, rapid rise time is not a problem.

Existing general purpose low-voltage motors may work fine with PWM ASDs if peak voltages due to ringing are held below 1000 volts. If high frequency voltage overshoots exceed 1000 volts, electrical stresses can cause a turn-to-turn short within a motor coil group, usually within the first couple of turns.

Voltage overshoot is best avoided by locating the drive close to the motor. If a short cable run is not possible, a filtering device must be used. Sometimes ASD manufacturers provide a filter device along with the drive or even in the drive cabinet. There are two commonly used filter arrangements—*line inductors* (sometimes called load reactors), which should be placed at the drive end of the cable, and *harmonic suppression filters*, which are placed at the motor end of the cable. There are some losses associated with the filters, so keeping cables short is still the best alternative.

The fast rise time pulses from a PWM ASD can also create a potentially harmful current flow in bearings even when over-voltage is not significant. Causes include common mode voltage problems and/or line voltage unbalance on the ASD input. Capacitive coupling, resulting from irregular current waveforms and ground-mode currents, can cause bearing failure due to rapid voltage changes and a high frequency voltage potential on the shaft causing current flow across the rolling elements of the motor's bearings. Problems can also occur in driven-load bearings if insulated couplings are not used. Eliminate these problems by isolating both bearings or using a shaft grounding brush.

BestPractices is part of the Industrial Technologies Program Industries of the Future strategy, which helps the country's most energy-intensive industries improve their competitiveness. BestPractices brings together emerging technologies and best energy-management practices to help companies begin improving energy efficiency, environmental performance, and productivity right now.

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FOR ADDITIONAL INFORMATION, PLEASE CONTACT:

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DOE/GO-102008-2621
July 2008